tronomer und Physiker gedruckt zu sehen, habe ich, als Nachfolger Ihres Vaters, jetzt in seiner Dienstwohnung befindlich, und als Herausgeber seiner grossen Werke, mir erlaubt Ihren Namen mit in die Liste einsetzen zu lassen. Es war nicht mehr Zeit Sie um Ihre Erlaubnis dazu zu fragen, aber es kann bei mir kein Zweifel sein über Ihre Genehmigung. Gerne werde ich mir erlauben, Ihnen weiteren Bericht über die Denkmalsfrage abzustatten, so bald etwas definitives feststeht.

Der Prinz Albrecht von Preussen, Prinz Regent vom Herzogthum Braunschweig, Rector Magnificentissimus von der Universität Göttingen, hat sich bereit finden lassen, das Protectorat der Commission für das Denkmal zu übernehmen. Er hat befohlen, dass aus Landesmitteln des Herzogthums Braunschweig 3000 Mk. für das Denkmal gegeben werden. Das ist ja ein sehr guter Anfang. In den Zeitungen habe ich die Notiz gelesen:

Gauss, E. F. L. erster Assistent von Frederik H. Hild dem Librarian of the Chicago Public Library. Gehört dieser Gauss auch zu der berühmten Familie?*

Da das Deutsche Reich sich auch amtlich an der grossen Ausstellung in Chicago betheiligt, so wird wahrscheinlich das Post—und Telegraphen—Museum in Berlin unter dem Reichsekretair von Stephan auch die Hauptstücke seiner geschichtlichen Sammlung dorthin senden. Darunter findet sich ein Gemälde von dem grossen Gauss und eine Reproduction sein s ersten Telegraphen. Jenes Gemälde ist Gauss sehr ähnlich, aber noch schöner finde ich das Gemälde, welches sich hier in seinem Erdmagnetischen Observatorium unter meinem Gewahrsam befindet. Es ist von der Preussischen Regierung zum 150 jährigen Jubilaeum der Universität Göttingen 1887 dem Institute geschenkt worden. Ueberhaupt war dieses Jubilaeum ein grossartiges Fest zur Verherrlichung von Gauss. Keine der vielen Tischreden, keine Festrede, keine Predigt wurde gehalten, ohne dass sein Name genannt und seine Erfindung des Electrischen Telegraphen erwähnt worden wäre. Seit jener Zeit befindet sich auch seine Marmortafel an der Sternwarte, Abtheilung des Erdmagnetischen Observatorium, mit der Aufschrift

Erster electrischer Telegraph
GAUSS—WEBER
Ostern, 1833

Mit den ergebensten Empfehlungen zeichne ich mich Ihr ERNST SCHERING,
Herausgeber der Gauss'schen Werke. Gemeinrath u. Professor.

FLORIAN CAJORI.
COLORADO COLLEGE, COLORADO SPRINGS.

* Mr. Robert Gauss, a son of Eugene Gauss and now managing editor of the *Denver Republican*, informs me that the E. F. L. Gauss in question is not a descendant of Gauss the mathematician. Schering's letter is in the possesssion of Robert Gauss, through whose kindness the writer was permitted to make a copy of it.

THE AGE OF THE EARTH AS AN ABODE FITTED FOR LIFE.

II.

PROBABLE ORIGIN OF GRANITE.

§ 26. UPON the suppositions we have hitherto made we have, at the stage now reached, all round the earth at the same time a red-hot or white-hot surface of solid granules or crystals with interstices filled by the mother liquor still liquid, but ready to freeze with the slightest cooling. The thermal conductivity of this heterogeneous mass, even before the freezing of the liquid part, is probably nearly the same as that of ordinary solid granite or basalt at a red heat, which is almost certainly* somewhat less than the thermal conductivity of igneous rocks at ordinary temperatures. If you wish to see for yourselves how quickly it would cool when wholly solidified take a large macadamizing stone, and heat it red hot in an ordinary coal fire. Take it out with a pair of tongs and leave it on the hearth, or on a stone slab at a distance from the fire, and you will see that in a minute or two, or perhaps in less than a minute, it cools to below red heat.

§ 27. Half an hour† after solidification reached up to the surface in any part of the earth, the mother liquor among the granules must have frozen to a depth of several centimeters below the surface and must have cemented together the granules and crystals, and so formed a crust of primeval granite, comparatively cool at its upper surface, and red hot to white hot, but still

* Proc. R. S., May 30, 1895.

† Witness the rapid cooling of lava running red hot or white hot from a volcano, and after a few days or weeks presenting a black, hard crust strong enough and cool enough to be walked over with impunity.

all solid, a little distance down; becoming thicker and thicker very rapidly at first; and after a few weeks certainly cold enough at its outer surface to be touched by the hand.

PROBABLE ORIGIN OF BASALTIC ROCK.*

§28. We have hitherto left, without much consideration, the mother liquor among the crystalline granules at all depths below the bottom of our shoaling lava ocean. It was probably this interstitial mother liquor that was destined to form the basaltic rock of future geological time. Whatever be the shapes and sizes of the solid granules when first falling to the bottom, they must have lain in loose heaps with a somewhat large proportion of space occupied by liquid among them. But, at considerable distances down in the heap, the weight of the superincumbent granules must tend to crush corners and edges into fine powder. If the snow shower had taken place in air we may feel pretty sure (even with the slight knowledge which we have of the hardnesses of the crystals of feldspar, mica and hornblende, and of the solid granules of quartz) that, at a depth of 10 kilometers, enough of matter from the corners and edges of the granules of different kinds, would have been crushed into powder of various degrees of fineness, to leave an exceedingly small proportionate volume of air in the interstices between the solid fragments. But in reality the effective weight of each solid particle, buoyed as it was by hydrostatic pressure of a liquid less dense than itself by not more than 20 or 15 or 10 per cent., cannot have been more than from about one-fifth to one-tenth of its weight in air, and therefore the same degree of crushing effect as would have been experienced at 10 kilometers with air in the interstices, must have been experienced only at depths of from 50 to 100 kilometers below the bottom of the lava ocean.

§29. A result of this tremendous crushing together of the solid granules must have been to press out the liquid from among them, as water from a sponge, and cause it to pass upwards through the less and less closely packed heaps of solid particles, and out into the lava ocean above the heap. But, on account of the great resistance against the liquid permeating upwards 30 or 40 kilometers through interstices among the solid granules, this process must have gone on somewhat slowly; and, during all the time of the shoaling of the lava ocean, there may have been a considerable proportion of the whole volume occupied by the mother liquor among the solid granules, down to even as low as 50 or 100 kilometers below the top of the heap, or bottom of the ocean, at each instant. When consolidation reached the surface, the oozing upwards of the mother liquor must have been still going on to some degree. Thus, probably for a few years after the first consolidation at the surface, not probably for as long as one hundred years, the settlement of the solid structure by mere mechanical crushing of the corners and edges of solid granules, may have continued to cause the oozing upwards of mother liquor to the surface through cracks in the first formed granite crust and through fresh cracks in basaltic crust subsequently formed above it.

LEIBNITZ'S CONSISTENTIOR STATUS.

§30. When this oozing everywhere through fine cracks in the surface ceases, we have reached Leibnitz's *consistentior status;* beginning with the surface cool and permanently solid and the temperature increasing to 1150° C. at 25 or 50 or 100 meters below the surface.

* See Addendum at end of Lecture.

PROBABLE ORIGIN OF CONTINENTS AND OCEAN DEPTHS OF THE EARTH.

§ 31. If the shoaling of the lava ocean up to the surface had taken place everywhere at the same time, the whole surface of the consistent solid would be the dead level of the liquid lava all round, just before its depth became zero. On this supposition there seems no possibility that our present-day continents could have risen to their present heights, and that the surface of the solid in its other parts could have sunk down to their present ocean depths, during the twenty or twenty-five million years which may have passed since the *consistentior status* began or during any time however long. Rejecting the extremely improbable hypothesis that the continents were built up of meteoric matter tossed from without, upon the already solidified earth, we have no other possible alternative than that they are due to heterogeneousness in different parts of the liquid which constituted the earth before its solidification. The hydrostatic equilibrium of the rotating liquid involved only homogeneousness in respect to density over every level surface (that is to say, surface perpendicular to the resultant of gravity and centrifugal force); it required no homogeneousness in respect to chemical composition. Considering the almost certain truth that the earth was built up of meteorites falling together, we may follow in imagination the whole process of shrinking from gaseous nebula to liquid larva and metals, and solidification of liquid from central regions outwards, without finding any thorough mixing up of different ingredients, coming together from different directions of space—any mixing up so thorough as to produce even approximately chemical homogeneousness throughout every layer of equal density. Thus we have no difficulty in understanding how even the gaseous nebula, which at one time constituted the matter of our present earth, had in itself a heterogeneousness from which followed by dynamical necessity Europe, Asia, Africa, America, Australia, Greenland and the Antarctic Continent, and the Pacific, Atlantic, Indian and Arctic Ocean depths, as we know them at present.

§ 32. We may reasonably believe that a very slight degree of chemical heterogeneousness could cause great differences in the heaviness of the snow shower of granules and crystals on different regions of the bottom of the lava ocean when still 50 or 100 kilometers deep. Thus we can quite see how it may have shoaled much more rapidly in some places than in others. It is also interesting to consider that the solid granules, falling on the bottom, may have been largely disturbed, blown as it were into ridges (like rippled sand in the bed of a flowing stream, or like dry sand blown into sand-hills by wind) by the eastward horizontal motion which liquid descending in the equatorial regions must acquire, relatively to the bottom, in virtue of the earth's rotation. It is, indeed, not improbable that this influence may have been largely effective in producing the general configuration of the great ridges of the Andes and Rocky Mountains and of the West Coasts of Europe and Africa. It seems, however, certain that the main determining cause of the continents and ocean-depths was chemical differences, perhaps very slight differences, of the material in different parts of the great lava ocean before consolidation.

§ 33. To fix our ideas let us now suppose that over some great areas such as those which have since become Asia, Europe, Africa, Australia and America, the lava ocean had silted up to its surface, while in other parts there still were depths ranging down to 40 kilometers at the deepest. In a very short time, say about twelve years according to our former estimate (§ 24), the

whole lava ocean becomes silted up to its surface.

§ 34. We have not time enough at present to think out all the complicated actions, hydrostatic and thermodynamic, which must accompany, and follow after, the cooling of the lava ocean surrounding our ideal primitive continent. By a hurried view, however, of the affair we see that in virtue of, let us say, 15 per cent. shrinkage by freezing, the level of the liquid must, at its greatest supposed depth, sink six kilometers relatively to the continents, and thus the liquid must recede from them, and their bounding coast-lines must become enlarged. And just as water runs out of a sandbank, drying when the sea recedes from it on a falling tide, so rivulets of the mother liquor must run out from the edges of the continents into the receding lava ocean. But, unlike sandbanks of incoherent sand permeated by water remaining liquid, our uncovered banks of white-hot solid crystals, with interstices full of the mother liquor, will, within a few hours of being uncovered, become crusted into hard rock by cooling at the surface, and freezing of the liquor, at a temperature somewhat lower than the melting temperatures of any of the crystals previously formed. The thickness of the wholly solidified crust grows at first with extreme rapidity, so that in the course of three or four days it may come to be as much as a meter. At the end of a year it may be as much as ten meters; with a surface, almost, or quite, cool enough for some kinds of vegetation. In the course of the first few weeks the régime of conduction of heat outwards becomes such that the thickness of the wholly solid crust, as long as it remains undisturbed, increases as the square root of the time; so that in 100 years it becomes 10 times, in 25 million years 5,000 times, as thick as it was at the end of one year; thus, from one year to 25 million years after the time of surface freezing, the thickness of the wholly solid crust might grow from 10 meters to 50 kilometers. These definite numbers are given merely as an illustration, but it is probable that they are not enormously far from the truth in respect to what has happened under some of the least disturbed parts of the earth's surface.

§ 35. We have now reached the condition described above in § 30, with only this difference, that instead of the upper surface of the whole solidified crust being level we have in virtue of the assumptions of §§ 33, 34, inequalities of 6 kilometers from highest to lowest levels, or as much more than 6 kilometers as we please to assume it.

§ 36. There must still be a small, but important, proportion of mother liquor in the interstices between the closely packed uncooled crystals below the wholly solidified crust. This liquor, differing in chemical constitution from the crystals, has its freezing-point somewhat lower, perhaps very largely lower, than the lowest of their melting-points. But, when we consider the mode of formation (§ 25) of the crystals, from the mother liquor, we must regard it as still always a solvent ready to dissolve, and to redeposit, portions of the crystalline matter, when slight variations of temperature or pressure tend to cause such actions. Now as the specific gravity of the liquor is less, by something like 15 per cent., than the specific gravity of the solid crystals, it must *tend* to find its way upwards, and will actually do so, however slowly, until stopped by the already solidified impermeable crust, or until itself becomes solid on account of loss of heat by conduction outwards. If the upper crust were everywhere continuous and perfectly rigid the mother liquor must, inevitably, if sufficient time be given, find its way to the highest places of the lower boundary of the crust, and there form gigantic pockets of liquid lava tending to

break the crust above it and burst up through it.

§ 37. But in reality the upper crust cannot have been infinitely strong; and, judging alone from what we know of properties of matter, we should expect gigantic cracks to occur from time to time in the upper crust tending to shrink as it cools and prevented from lateral shrinkage by the non-shrinking uncooled solid below it. When any such crack extends downwards as far as a pocket of mother liquor underlying the wholly solidified crust, we should have an outburst of trap rock or of volcanic lava just such as have been discovered by geologists in great abundance in many parts of the world. We might even have comparatively small portions of high plateaus of the primitive solid earth raised still higher by outbursts of the mother liquor squeezed out from below them in virtue of the pressure of large surrounding portions of the superincumbent crust. In any such action, due to purely gravitational energy, the center of gravity of all the material concerned must sink, although portions of the matter may be raised to greater heights; but we must leave these large questions of geological dynamics, having been only brought to think of them at all just now by our consideration of the earth antecedent to life upon it.

§ 38. The temperature to which the earth's surface cooled within a few years after the solidification reached it must have been, as it is now, such that the temperature at which heat radiated into space during the night exceeds that received from the sun during the day by the small difference due to heat conducted outwards from within.* One year after the freezing of the granitic interstitial mother liquor at the earth's surface in any locality the average temperature at the surface might be warmer, by 60° or 80° Cent., than if the whole interior had the same average temperature as the surface. To fix our ideas, let us suppose at the end of one year the surface to be 80° warmer than it would be with no underground heat; then at the end of 100 years it would be 8° warmer, and at the end of 10,000 years it would be ·8 of a degree warmer, and at the end of 25 million years it would be ·016 of a degree warmer, than if there were no underground heat.

§ 39. When the surface of the earth was still white-hot liquid all round, at a temperature fallen to about 1200° Cent., there must have been hot gases and vapor of water above it in all parts, and possibly vapors of some of the more volatile of the present known terrestrial solids and liquids, such as zinc, mercury, sulphur, phosphorus. The very rapid cooling which followed instantly on the solidification at the surface

* Suppose, for example, the cooling and thickening of the upper crust has preceeded so far that at the surface, and, therefore, approximately for a few decimetres below the surface, the rate of augmentation of temperature downwards is one degree per centimeter. Taking as a rough average ·005 c. g. s. as the thermal conductivity of the surface rock, we should have for the heat conducted outwards ·005 of a gramme water thermal unit Centigrade per sq. cm. per sec. (Kelvin Math. and Phys. Papers, Vol. III., p. 226). Hence, if (ibid. p. 223) we take $\frac{1}{8000}$ as the radiational emissivity of rock and atmosphere of gases and watery vapor above it radiating heat into the surrounding vacuous space (æther), we find 8000 × ·005 or 40 degrees Cent. as the excess of the mean surface temperature above what it would be if no heat were conducted from within outwards. The present augmentation of temperature downwards may be taken as 1 degree Cent. per 27 meters as a rough average derived from observations in all parts of the earth where underground temperature has been observed. (See British Association Reports from 1868 to 1895. The very valuable work of this Committee has been carried on for these twenty-seven years, with great skill, perseverance and success, by Professor Everett, and he promises a continuation of his reports from time to time.) This, with the same data for conductivity and radiational emissivity as in the preceding calculation, makes 40°/2700 or 0.0148° Cent. per centimeter as the amount by which the average temperature of the earth's surface is at present kept up by underground heat.

must have caused a rapid downpour of all the vapors other than water, if any there were; and, a little later, rain of water out of the air, as the temperature of the surface cooled from red heat to such moderate temperatures as 40° and 20° and 10° Cent. above the average due to sun heat and radiation into the ether around the earth. What that primitive atmosphere was, and how much rain of water fell on the earth in the course of the first century after consolidation, we cannot tell for certain; but Natural History and Natural Philosophy give us some foundation for endeavors to discover much towards answering the great questions: Whence came our present atmosphere of nitrogen, oxygen and carbonic acid? Whence came our present oceans and lakes of salt and fresh water? How near an approximation to present conditions was realized in the first hundred centuries after consolidation of the surface.

§ 40. We may consider it as quite certain that nitrogen gas, carbonic acid gas and steam, escaped abundantly in bubbles from the mother liquor of granite, before the primitive consolidation of the surface, and from the mother liquor squeezed up from below in subsequent eruptions of basaltic rock, cause all, or nearly all, specimens of granite and basaltic rock which have been tested by chemists in respect to this question,* have been found to contain, condensed in minute cavities within them, large quantities of nitrogen, carbonic acid and water. It seems that in no specimen of granite or basalt tested has chemically free oxygen been discovered, while in many, chemically free hydrogen has been found, and either native iron or magnetic oxide of iron in those which do contain hydrogen. From this it might seem probable that there was no free oxygen in the primitive atmosphere, and that if there was free hydrogen it was due to the decomposition of steam by iron or magnetic oxide of iron. Going back to still earlier conditions we might judge that, probably, among the dissolved gases of the hot nebula which became the earth, the oxygen all fell into combination with hydrogen and other metallic vapors in the cooling of the neubla, and that, although it is known to be the most abundant material of all the chemical elements constituting the earth, none of it was left out of combination with other elements to give free oxygen in our primitive atmosphere.

§ 41. It is, however, possible, although it might seem not probable, that there was free oxygen in the primitive atmosphere. With or without free oxygen, however, *but with sunlight*, we may regard the earth as fitted for vegetable life as now known in some species, wherever water moistened the newly solidified rocky crust cooled down below the temperature of 80° or 70° of our present Centigrade thermometric scale a year or two after solidification of the primitive lava had come up to the surface. The thick, tough, velvety coating of living vegetable matter, covering the rocky slopes under hot water flowing direct out of the earth at Banff (Canada),* lives without help from any ingredients of the atmosphere above it, and takes from the water and from carbonic acid or carbonates, dissolved in it, the hydrogen and carbon needed for its own growth by the dynamical power of sunlight; thus leaving free oxygen in the water to pass ultimately into the air. Similar vegetation is found abundantly on the terraces of the Mammoth hot springs and on the beds of the hot-water streams flowing from the Geysers in the Yellowstone National Park of the United States. This vegetation, consisting of confervæ, all grows

*See, for example, Tilden, Proc. R. S. February 4, 1897: 'On the Gases Enclosed in Crystalline Rocks and Minerals.'

* Rocky Mountains Park of Canada, on the Canadian Pacific Railway.

under flowing water at various temperatures, some said to be as high as 74° Cent. We cannot doubt but that some such confervæ, if sown or planted in a rivulet or pool of warm water in the early years of the first century of the solid earth's history, and, if favored with sunlight, would have lived, and grown, and multiplied, and would have made a beginning of oxygen in the air, if there had been none of it before their contributions. Before the end of the century, if sun-heat, and sunlight, and rainfall were suitable, the whole earth not under water must have been fitted for all kinds of land plants which do not require much or any oxygen in the air, and which can find, or make, place and soil for their roots on the rocks on which they grow; and the lakes or oceans formed by that time must have been quite fitted for the life of many or all of the species of water plants living on the earth at the present time. The moderate warming, both of land and water, by underground heat, towards the end of century, would probably be favorable rather than adverse to vegetation, and there can be no doubt but that if abundance of seeds of all species of the present day had been scattered over the earth at that time an important proportion of them would have lived and multiplied by natural selection of the places where they could best thrive.

§42. But if there was no free oxygen in in the primitive atmosphere or primitive water several thousands, possibly hundreds of thousands, of years must pass before oxygen enough for supporting animal life, as we now know it, was produced. Even if the average activity of vegetable growth on land and in water over the whole earth was, in those early times, as great in respect to evolution of oxygen as that of a Hessian forest, as estimated by Liebig* 50 years ago, or of a cultivated English hayfield of the present day, a very improbable supposition, and if there were no decay (*eremacausis*, or gradual recombination with oxygen) of the plants or of portions, such as leaves falling from plants, the rate of evolution of oxygen, reckoned as three times the weight of the wood or the dry hay produced, would be only about 6 tons per English acre per annum or $1\frac{1}{2}$ tons per square meter per thousand years. At this rate it would take only 1533 years, and, therefore, in reality a much longer time would almost certainly be required, to produce the 2.3 tons of oxygen which we have at present resting on every square meter of the earth's surface, land and sea.* But probably quite a moderate number of hundred thousand years may have sufficed. It is interesting, at all events, to remark that, at any time, the total amount of combustible material on the earth, in the form of living plants or their remains left dead, must have been just so much that to burn it all would take either the whole oxygen of the atmosphere or the excess of oxygen in the atmosphere at the time above that, if any, which there was in the beginning. This we can safely say, because we almost certainly neglect nothing considerable in comparison with what we assert when we say that the free oxygen of the earth's atmosphere is augmented only by vegetation liberating it from carbonic acid and water, in virtue of the power of sunlight, and is diminished only by virtual burning† of the

* Liebig, 'Chemistry in its application to Agriculture and Physiology.' English, 2d ed., edited by Playfair, 1842.

* In our present atmosphere, in average conditions of barometer and thermometer, we have, resting on each square meter of the earth's surface, ten tons total weight, of which 7.7 is nitrogen and 2.3 is oxygen.

† This 'virtual burning' includes eremacausis of decay of vegetable matter, if there is any eremacausis of decay without the intervention of microbes or other animals. It also includes the combination of a portion of the food with inhaled oxygen in the regular animal economy of provision for heat and power.

vegetable matter thus produced. But it seems improbable that the average of the whole earth—dry land and sea bottom—contains at present coal, or wood, or oil, or fuel of any kind, originating in vegetation, to so great an amount as .767 of a ton per square meter of surface; which is the amount, at the rate of one ton of fuel to three tons of oxygen, that would be required to produce the 2.3 tons of oxygen per square meter of surface which our present atmosphere contains. Hence it seems probable that the earth's primitive atmosphere must have contained free oxygen.

§ 43. Whatever may have been the true history of our atmosphere it seems certain that if sunlight was ready the earth was ready, both for vegetable and animal life, if not within a century, at all events within a few hundred centuries, after the rocky consolidation of its surface. But was the sun ready? The well-founded dynamical theory of the sun's heat carefully worked out and discussed by Helmholtz, Newcomb and myself,* says NO if the consolidation of the earth took place as long as 50 million years; the solid earth must in that case have waited 20 or 50 million years for the sun to be anything nearly as warm as he is at present. If the consolidation of the earth was finished 20 or 25 million years ago the sun was probably ready, though probably not then quite so warm as at present, yet warm enough to support some kind of vegetable and animal life on the earth.

§ 44. My task has been rigorously confined to what, humanly speaking, we may call the fortuitous concourse of atoms, in the preparation of the earth as an abode fitted for life, except in so far as I have referred to vegetation, as possibly having been concerned in the preparation of an atmosphere suitable for animal life as we now have it. Mathematics and dynamics fail us when we contemplate the earth, fitted for life but lifeless, and try to imagine the commencement of life upon it. This certainly did not take place by any action of chemistry, or electricity, or crystalline grouping of molecules under the influence of force, or by any possible kind of fortuitous concourse of atoms. We must pause, face to face with the mystery and miracle of the creation of living creatures.

*See 'Popular Lectures and Addresses,' Vol. I., pp. 376–429, particularly page 397.

ADDENDUM.—MAY, 1898.

Since this lecture was delivered I have received from Professor Roberts-Austen the following results of experiments on the melting-points of rocks which he has kindly made at my request:

	Melting-point.	Error.
Felspar	1520° C.	±30°
Hornblende	about 1400°	
Mica	1440°	±30°
Quartz	1775°	±15°
Basalt	about 880°	

These results are in conformity with what I have said in §§ 26–28 on the probable origin of granite and basalt, as they show that basalt melts at a much lower temperature than felspar, hornblende, mica or quartz, the crystalline ingredients of granite. In the electrolytic process for producing aluminium, now practiced by the British Aluminium Company at their Foyers works, alumina, of which the melting-point is certainly above 1700° C. or 1800° C., is dissolved in a bath of melted cryolite at a temperature of about 800° C. So we may imagine melted basalt to be a solvent for felspar, hornblende, mica and quartz at temperatures much below their own separate melting-points; and we can understand how the basaltic rocks of the earth may have resulted from the solidification of the mother liquor from which the crystalline ingredients of granite have been deposited.

KELVIN.